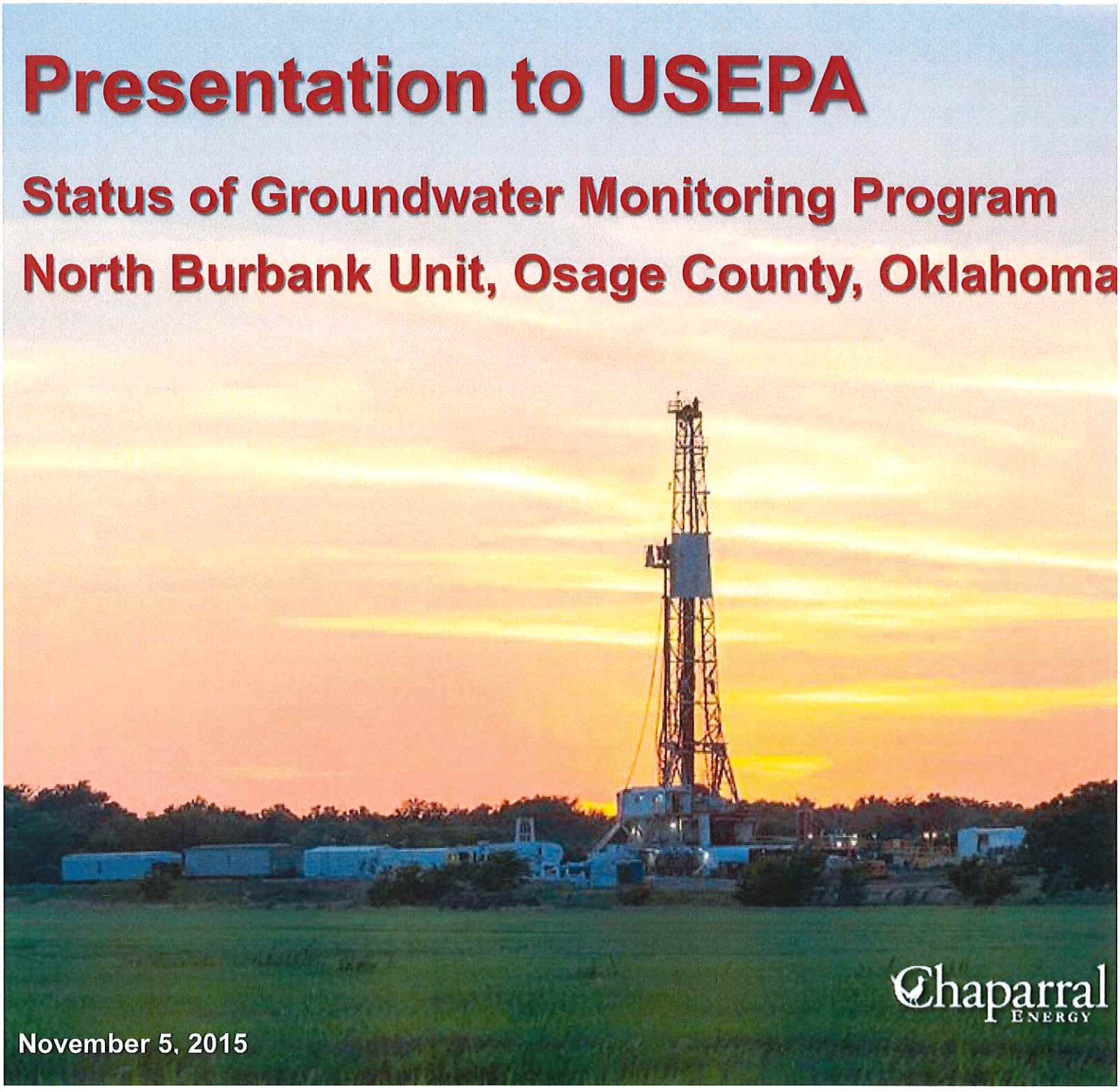
Presentation to USEPA

Status of Groundwater Monitoring Program

North Burbank Unit, Osage County, Oklahoma



November 5, 2015

Presentation to USEPA

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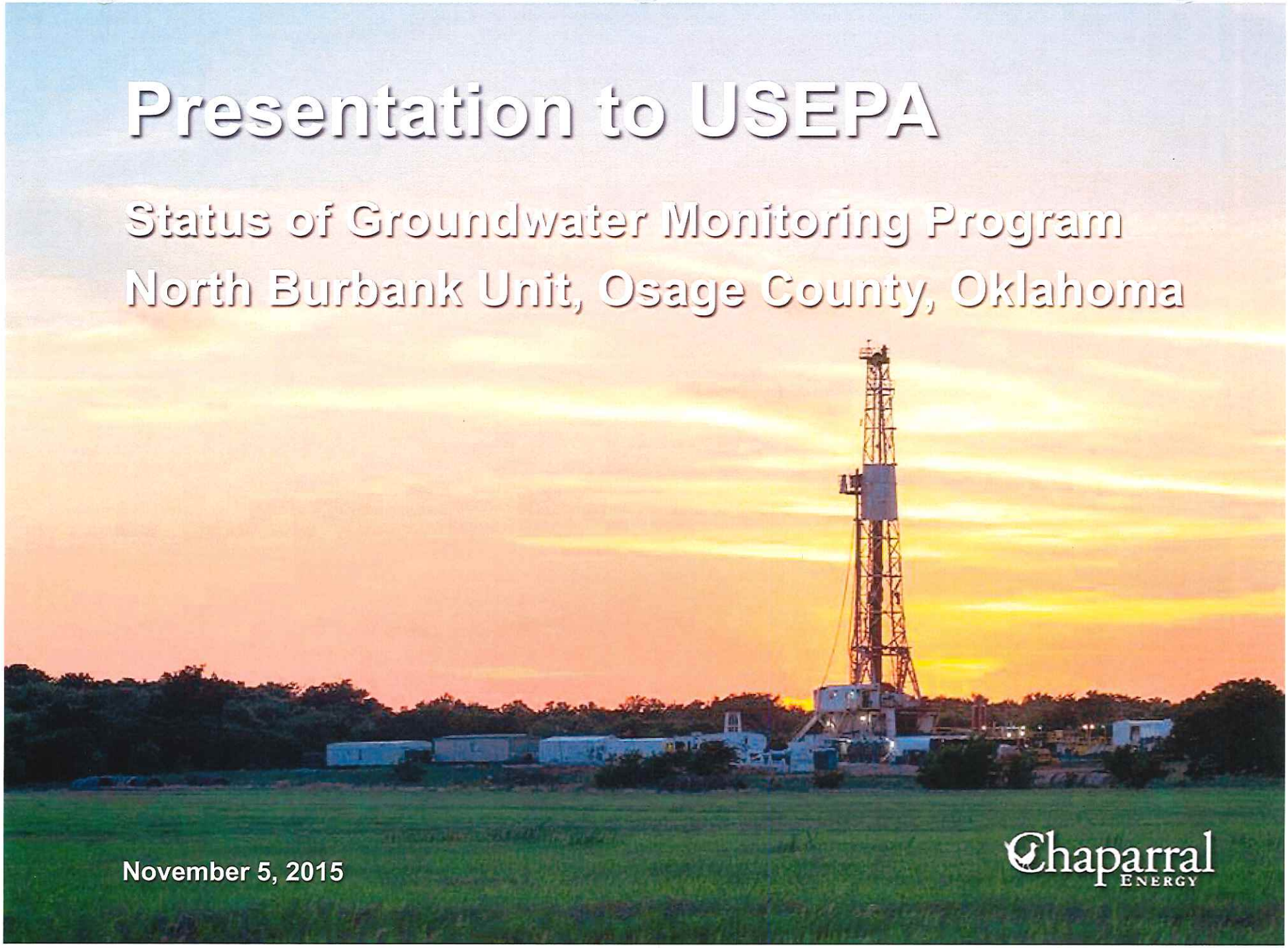

November 5, 2015

Chaparral ENERGY

Chaparral ENERGY | EPA Permit – Issued and Effective April 3, 2012

The Permit provided the following regarding groundwater monitoring requirements:

- Established a permit area of approximately 1,600 acres centered around Section 14, Township 27 North, Range 5 East, Osage County, Oklahoma
- Identified the base of underground sources of drinking water (USDW) to be at 245 feet below ground surface in the permit area.
- Required the installation one groundwater monitoring well to be placed at the intersection of all quarter section in the permit area to detect fluid migration into the USDWs.
- Monitoring wells should be in place before initiating CO_2 injection, or when the static fluid level in the injection zone exceeds the base of the USDW, whichever comes first.
- Monitoring wells were to be drilled to the base of the USDW and be constructed to allow collection of groundwater samples at 10 feet above the base of the USDW. A screen length of 20 feet was to be set at the base of the lowest water bearing formation encountered when drilling the well.

Chaparral Energy | EPA Permit – Issued and Effective April 3, 2012

Previous Slide - Continued

- Wells are to be monitored quarterly including measuring the depths to static groundwater, and collecting groundwater samples and analyzing them for chloride, total dissolved solids (TDS) and alkalinity.
- Chaparral was to utilize the first sampling results from all monitoring wells in a quarter section to establish baseline groundwater quality for that monitoring well. The first quarterly sample must be acquired prior to injection in the quarter section.
- If at the end of two years of monitoring the results of these analyzes do not exceed thirty percent of the baseline levels the frequency of sampling could be reduced to annual events with approval by the Chief.
- Quarterly monitoring reports are to be submitted to EPA according to a prescribed reporting schedule.
- Verbal report to EPA is required within 24 hours of receiving analytical results that exceed a thirty percent increase above baseline values followed by a written report within 5 days of the oral report providing the status of the investigation into the increases and any subsequent corrective actions proposed to protect the USDWs.

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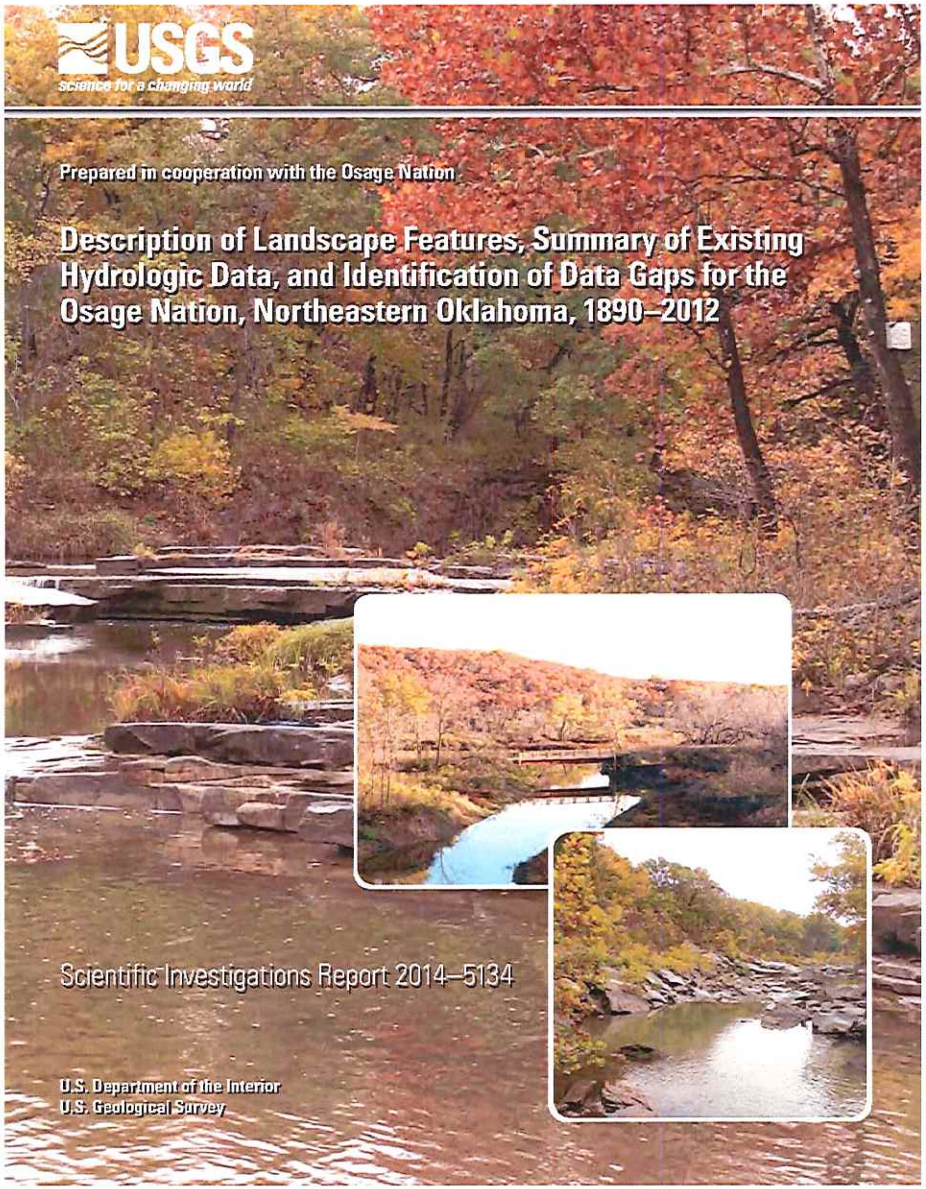
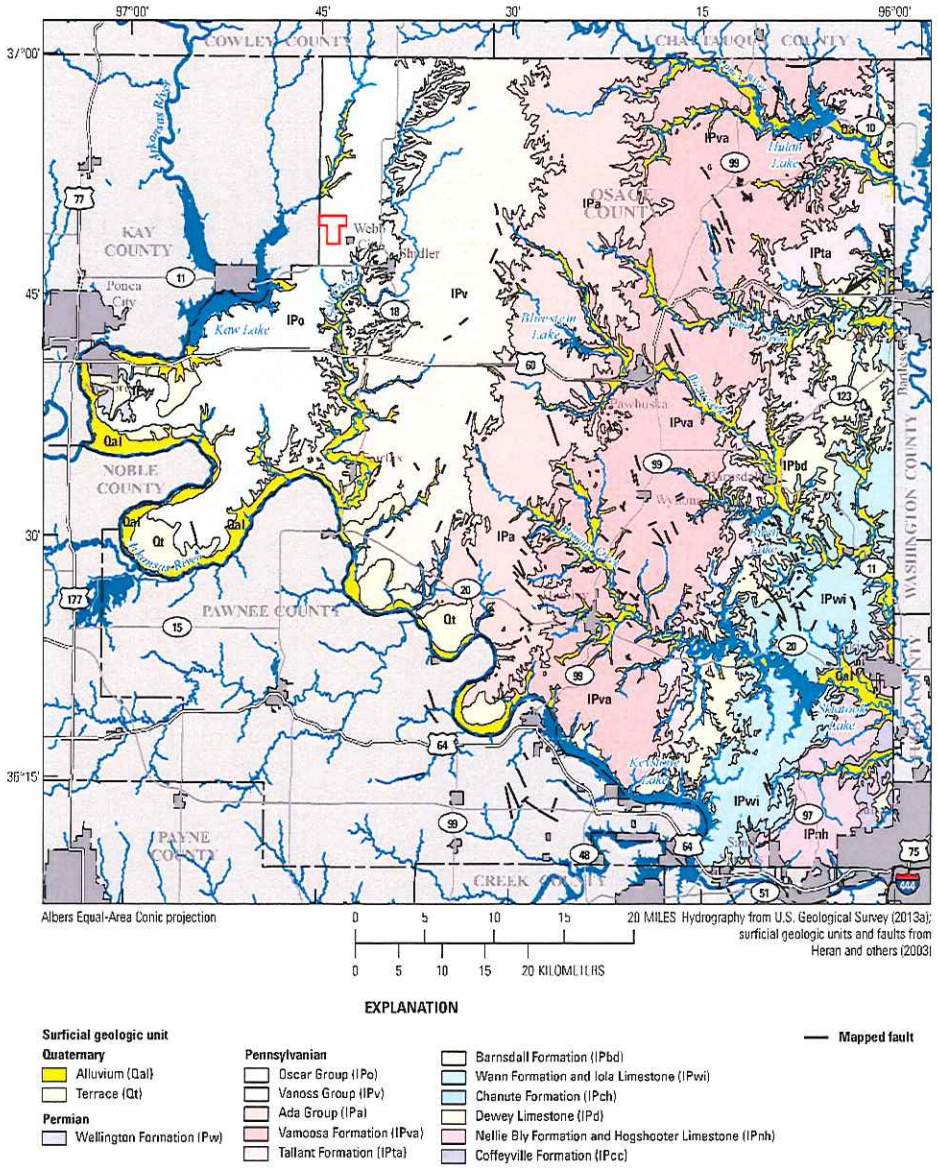
USGS 2014 Report

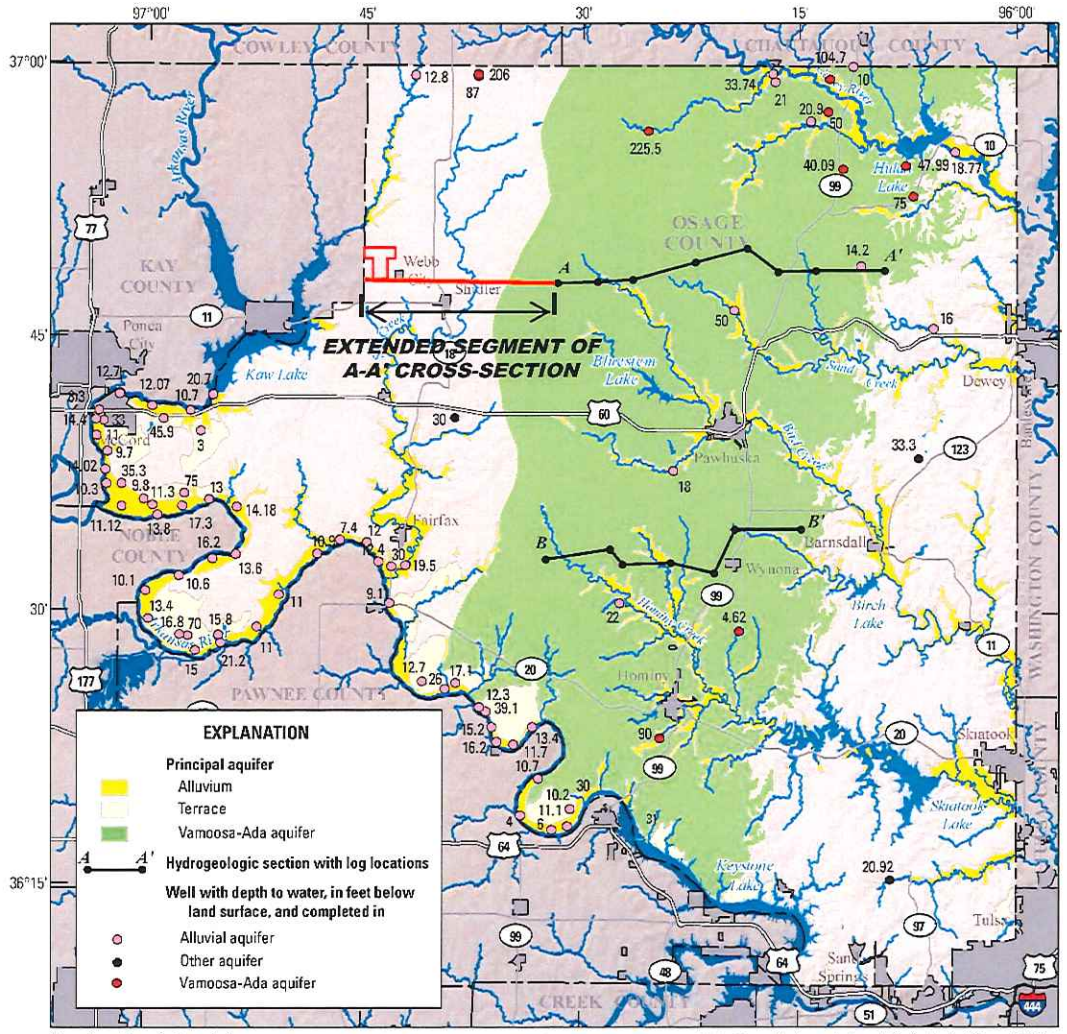


by
William J. Andrews
And
S. Jerrod Smith

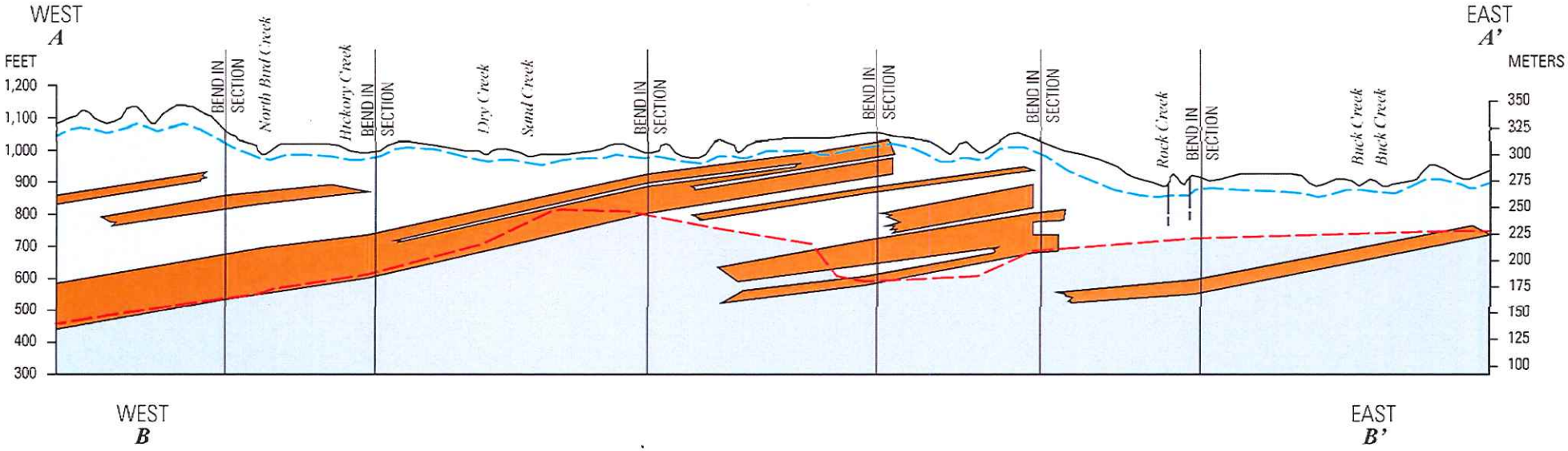
Geological Map (Andrews and Smith)



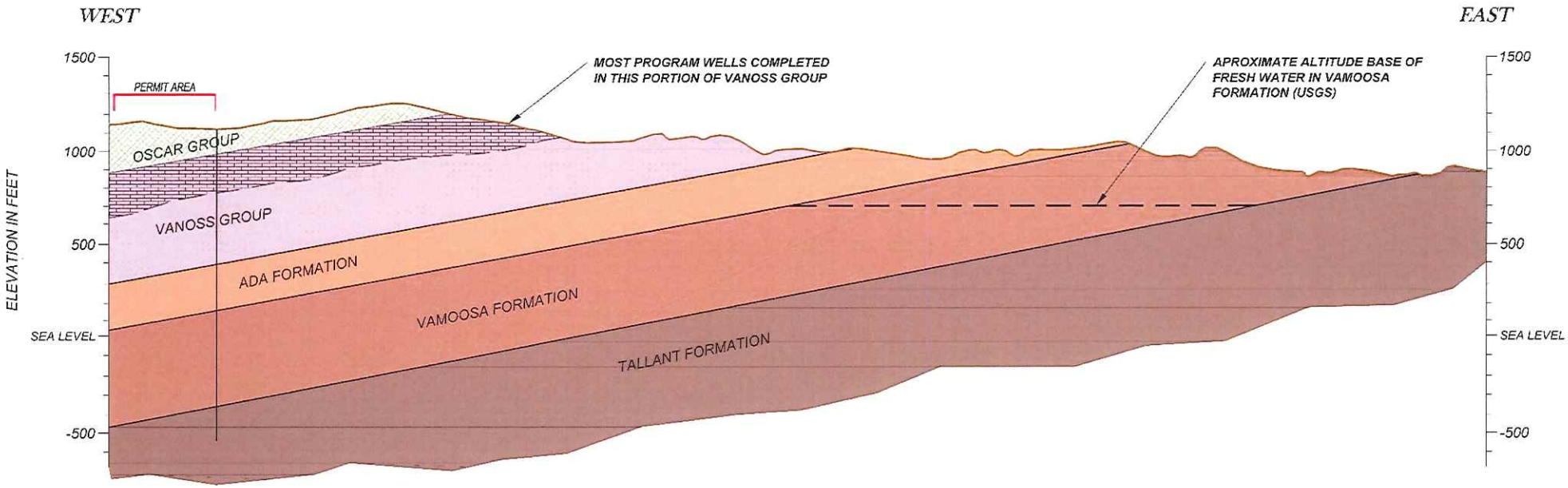
Principal Aquifers (Andrews and Smith)



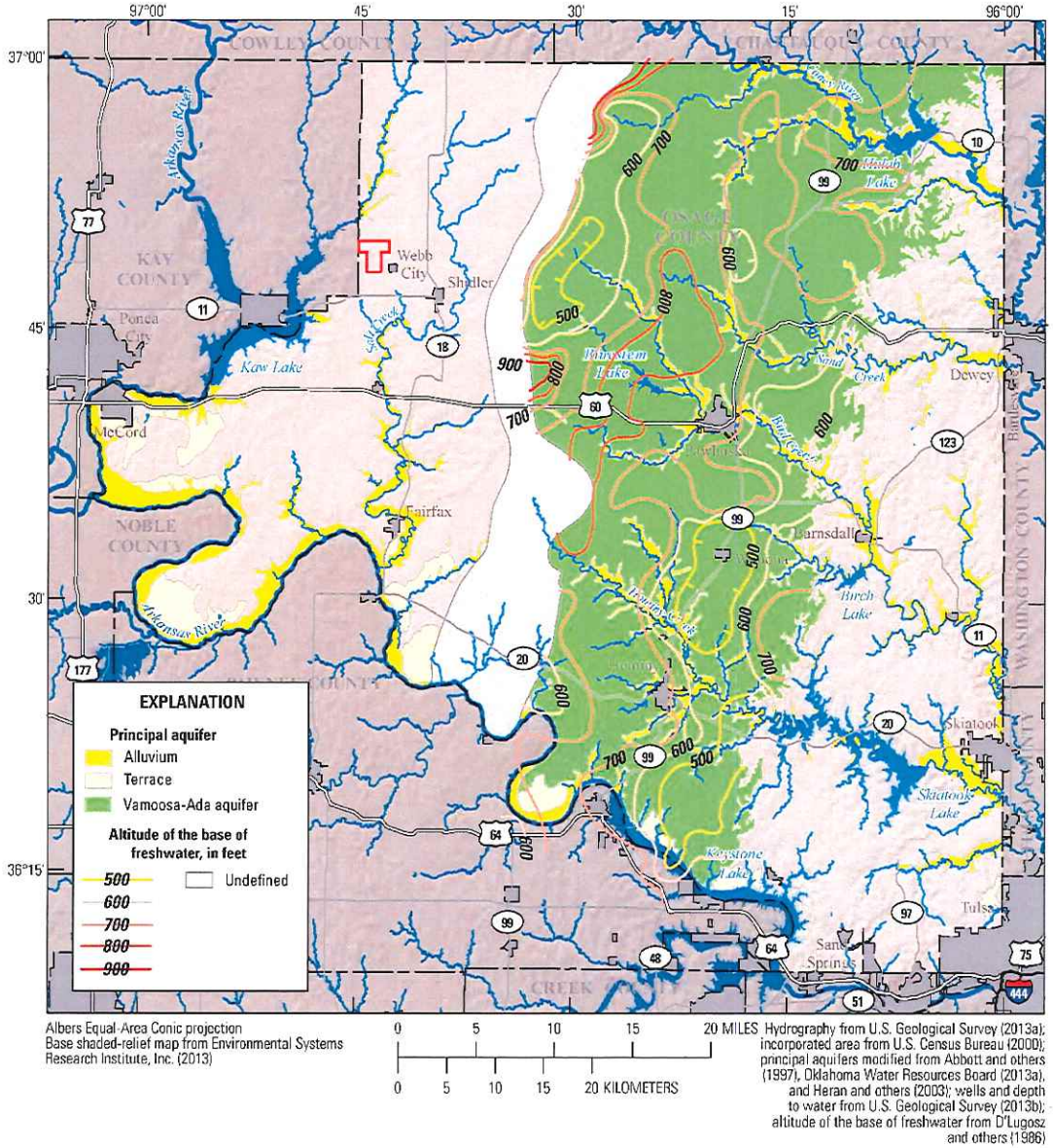
West-to-East Geologic Cross-Section – Regional (Andrews and Smith)



West-to-East Geologic Cross-Section – Regional (Modified)



Limits of Vamoosa-Ada Aquifer (Andrews and Smith)



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Installation of Monitoring Well Network

- Monitoring wells MW-1 through MW-19 installed August 1 through August 29, 2012 (Tier 1)
- Monitoring wells MW-20 through MW-29 installed August 1 through July 9, 2013 (Tier 2)
- Monitoring wells 30 through MW-38 installed June 25 through July 18, 2014 (Tier 3)
- Network currently has 38 groundwater monitoring wells
- Well depths range from 148 feet to 290 feet below ground surface
- Groundwater sampling began October 2012
- Tier 1 wells sampled 9 times
- Tier 2 wells sampled 8 times
- Tier 3 wells sampled 5 times
- Wells purged using low-flow purging methods
- Groundwater samples analyzed for alkalinity, chloride and TDS

38 Program Monitoring Wells

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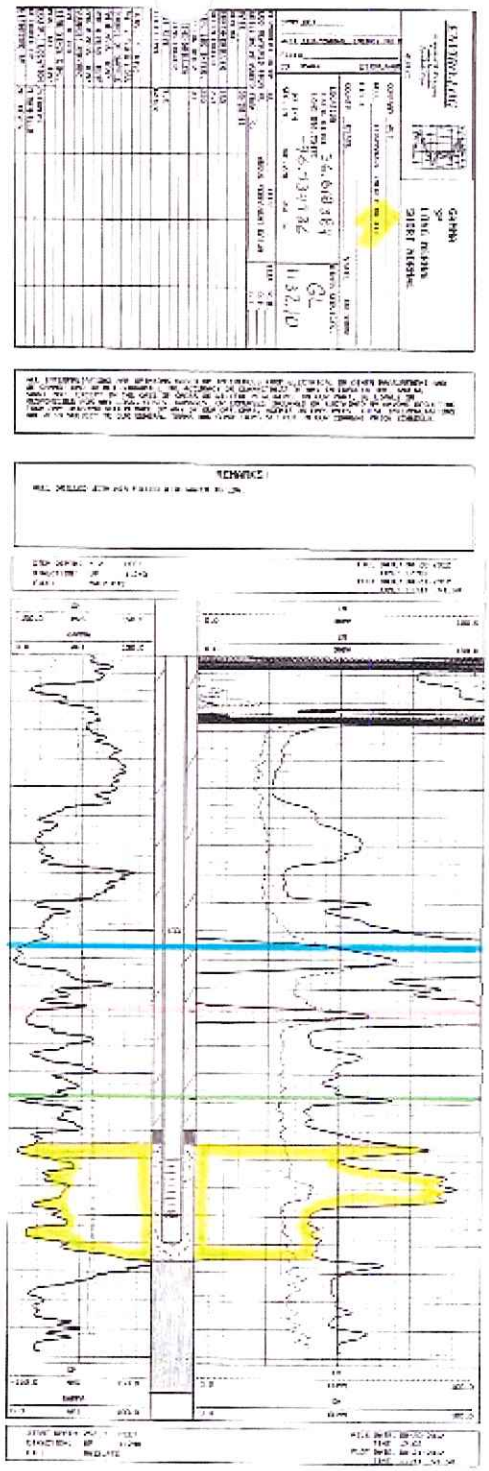
Analysis of Openhole Geophysical Surveys GR, SP, SN and LN



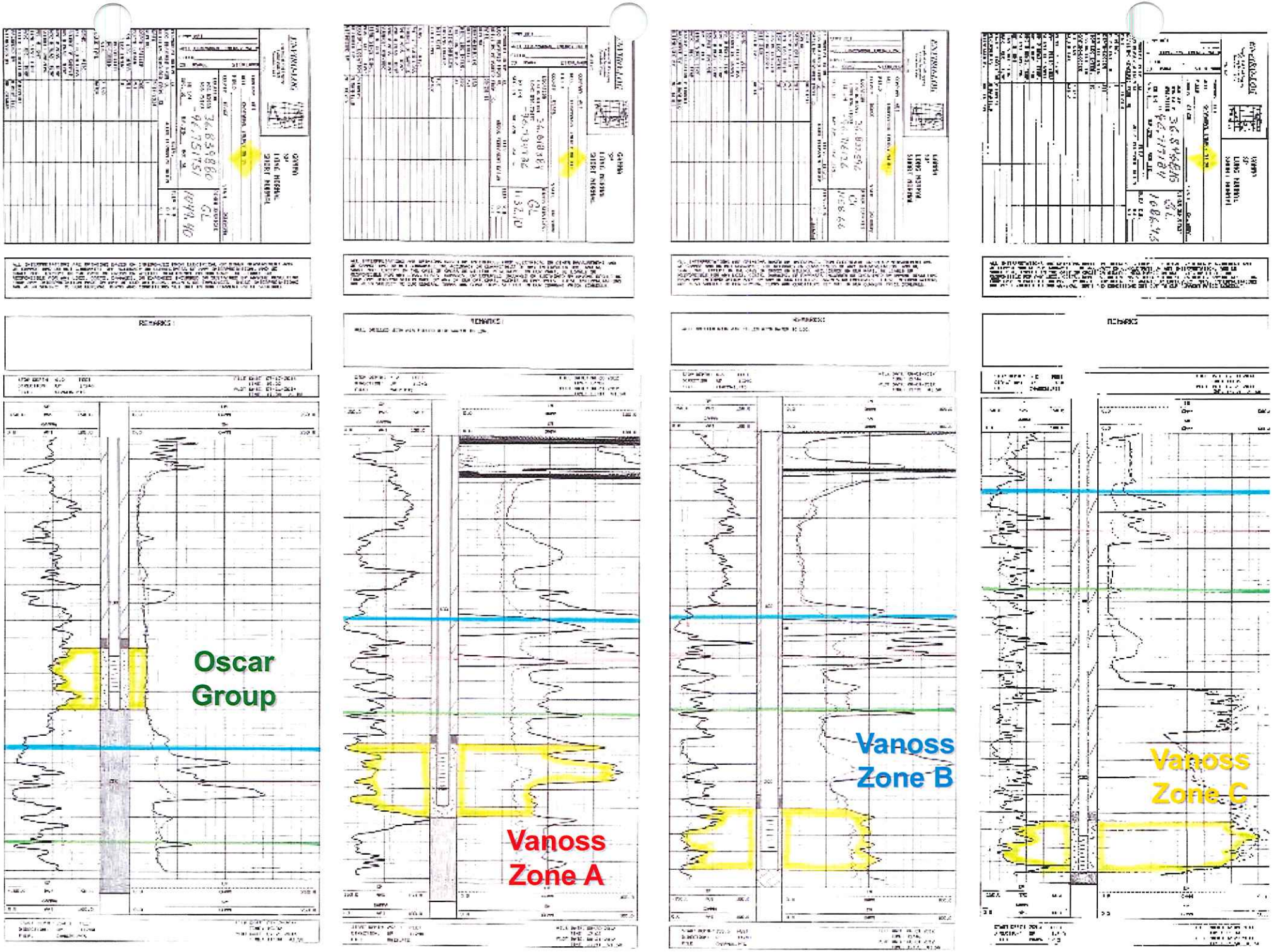
Approximate Top of Vanoss Group

Vanoss Sandstone Zones Below

Limestone Marker A

Limestone Marker B

Limestone Marker C


Oscar
Group
Vanoss
Zone A
Vanoss
Zone B
Vanoss
Zone C

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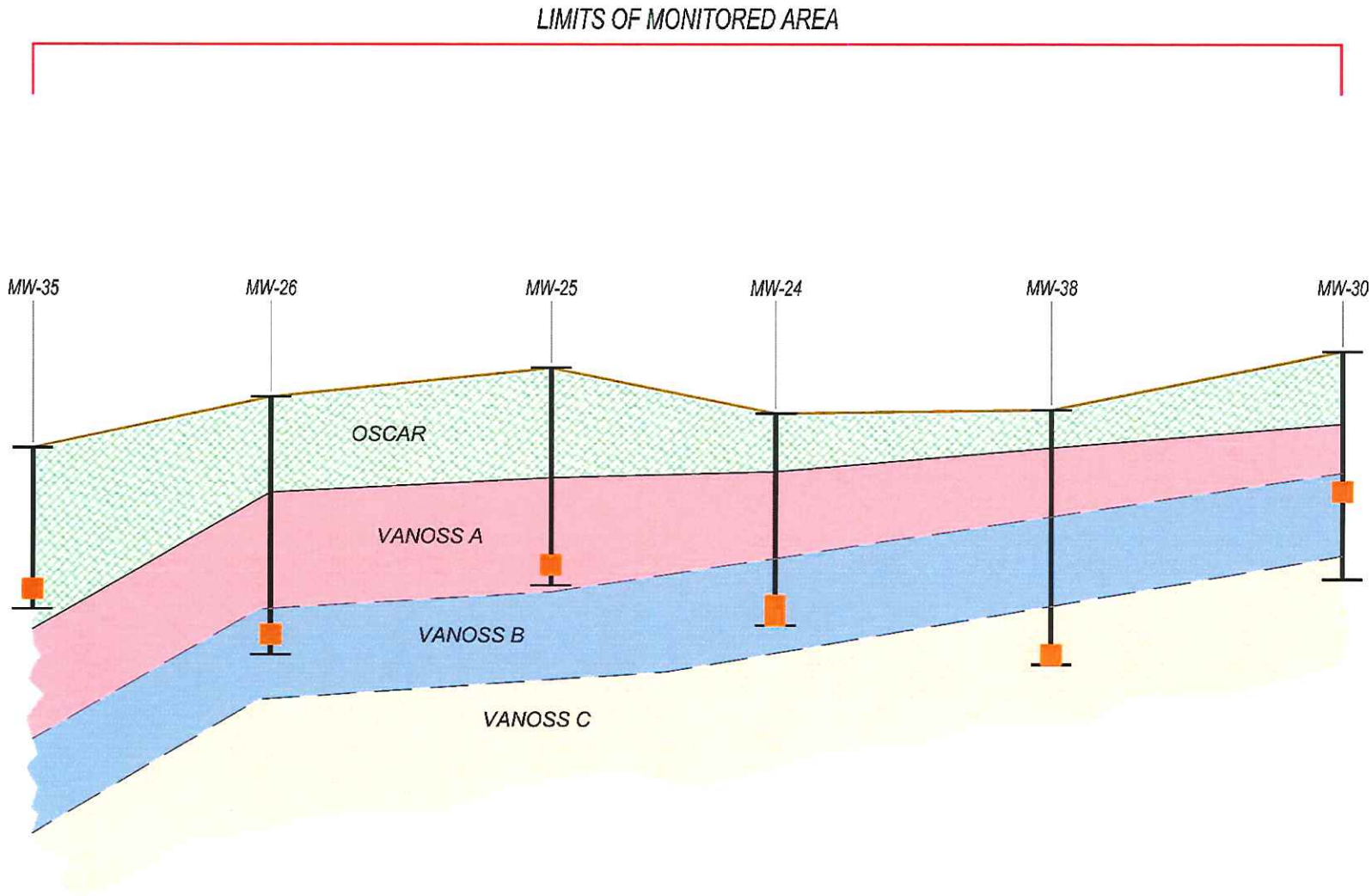
Pertinent Geologic Units

- Based Upon USGS Geologic Map, Regional Dip of 35 Feet/Mile and Outcrop Patterns, the Formations at the Surface and Underlying the Surface in Permit Area Generally are as Follows:
  - **Oscar Group** from surface to approximately 100 feet below ground surface
  - **Vanoss Group** from approximately 100 to 700 feet below ground surface
  - **Ada Formation** from approximately 700 to 900 feet below ground surface
  - **Vamoosa Formation** from approximately 900 to 1,400 feet below ground surface
  - **Red Fork Sandstone** and **Bartlesville Sandstone** (locally referred to as the Burbank Sands collectively) from approximately 3,000 to 3,100 feet below ground surface.

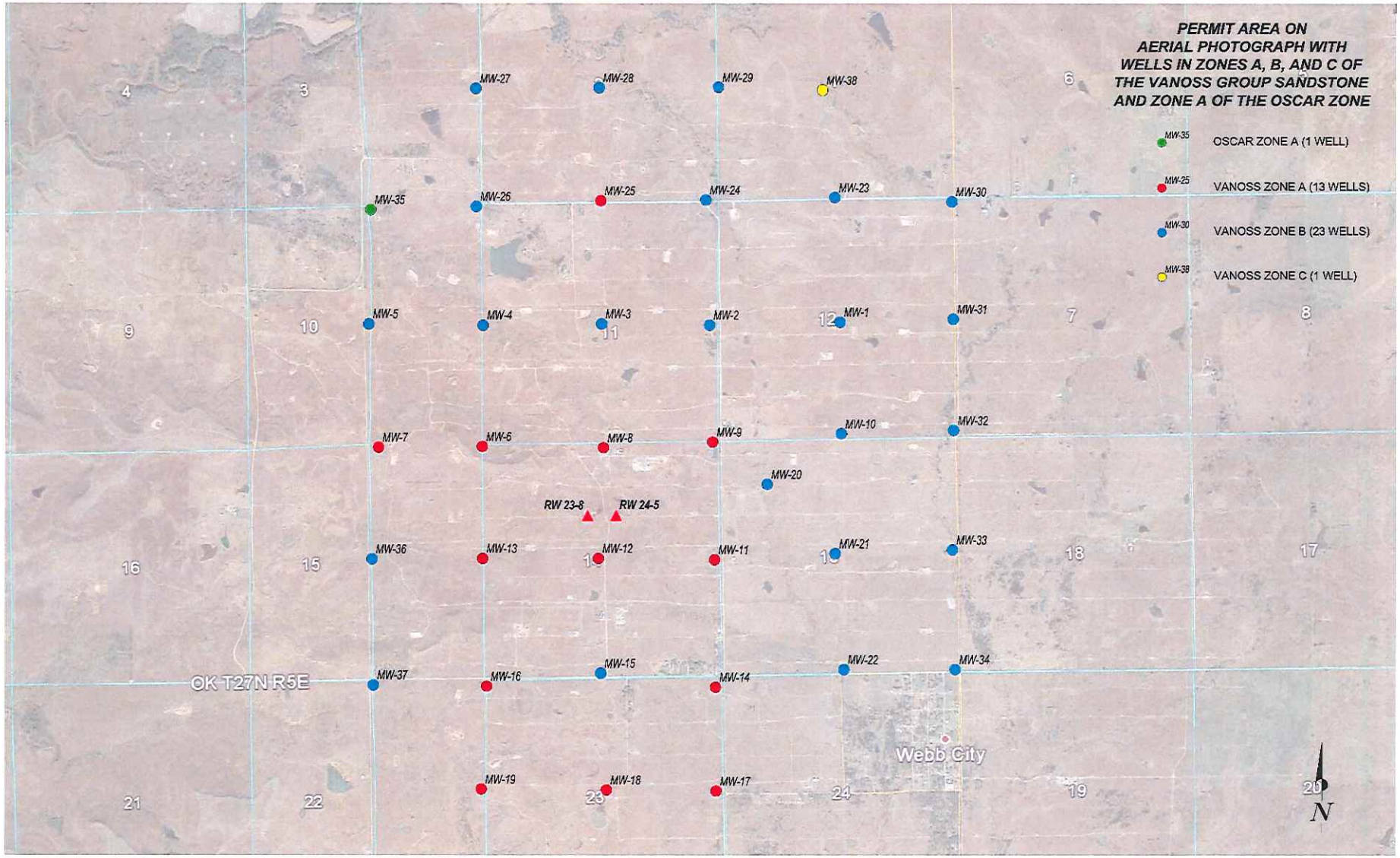
West-to-East Geologic Cross-Section – Permit Area



Stratigraphic Section

- Of the 38 groundwater monitoring wells installed pursuant to the EPA's UIC Area Permit, they appear to be completed in the following stratigraphic units:
  - **Oscar Group – Zone A (1 well): MW-35**
  - **Vanoss Group – Zone A (13 wells): MW-6, 7, 8, 9, 11, 12, 13, 14, 16, 17, 18, 19 and 25.**
  - **Vanoss Group – Zone B (23 wells): MW-1, 2, 3, 4, 5, 10, 15, 20, 21, 22, 23, 24, 26, 27, 28, 29, 30, 31, 32, 33, 34, 36 and 37.**
  - **Vanoss Group – Zone C (1 well): MW-38.**

Stratigraphic Section



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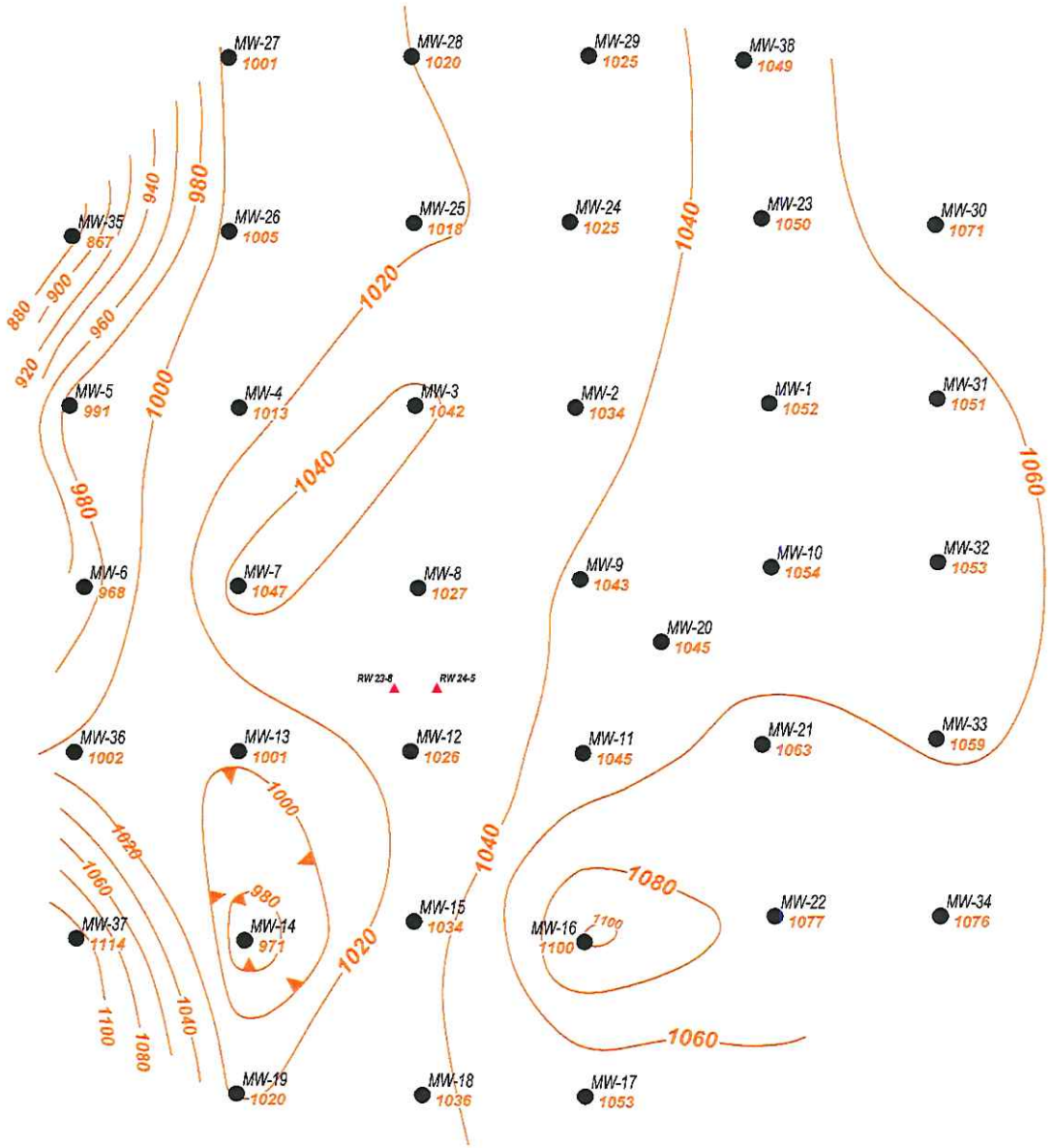
Bedrock Structure

BEDROCK STRUCTURE MAP
TOP OF MARKER A, FEET AMSL



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Geophysical Survey Analysis

- Bedrock dips towards the west at approximately 27 to 35 feet per mile across the permit area.
- At the northeast corner of Webb City (well MW-34) bedrock **Marker A** is 17 feet below ground surface. It outcrops at surface approximately ½ mile east of this location.
- Vanoss Group Sandstone **Zone A** is 67 feet below ground surface. It outcrops at surface approximately 2.5 miles east of this location.
- Vanoss Group Sandstone **Zone B** is 107 feet below ground surface. It outcrops at surface approximately 4 miles east of this location.

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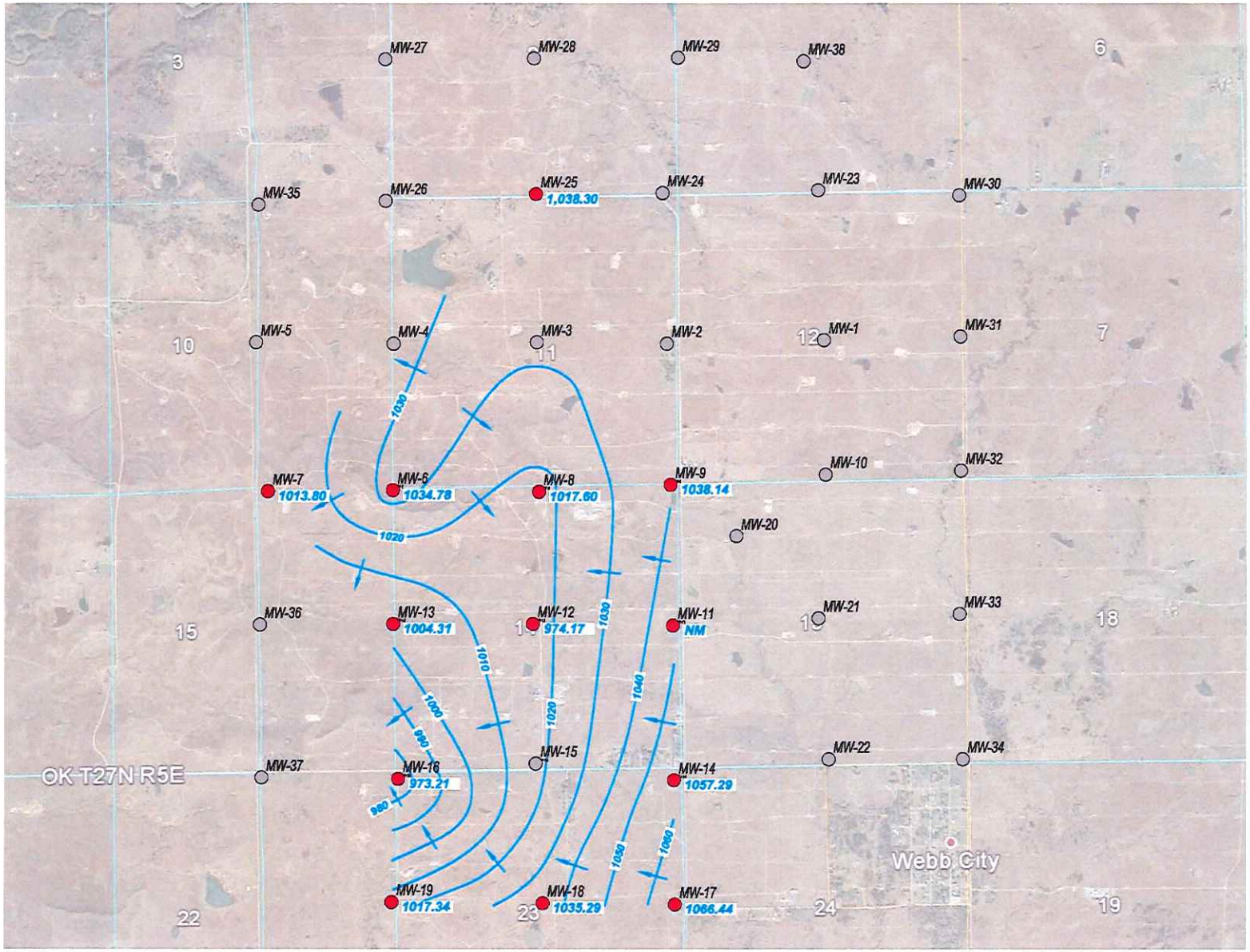
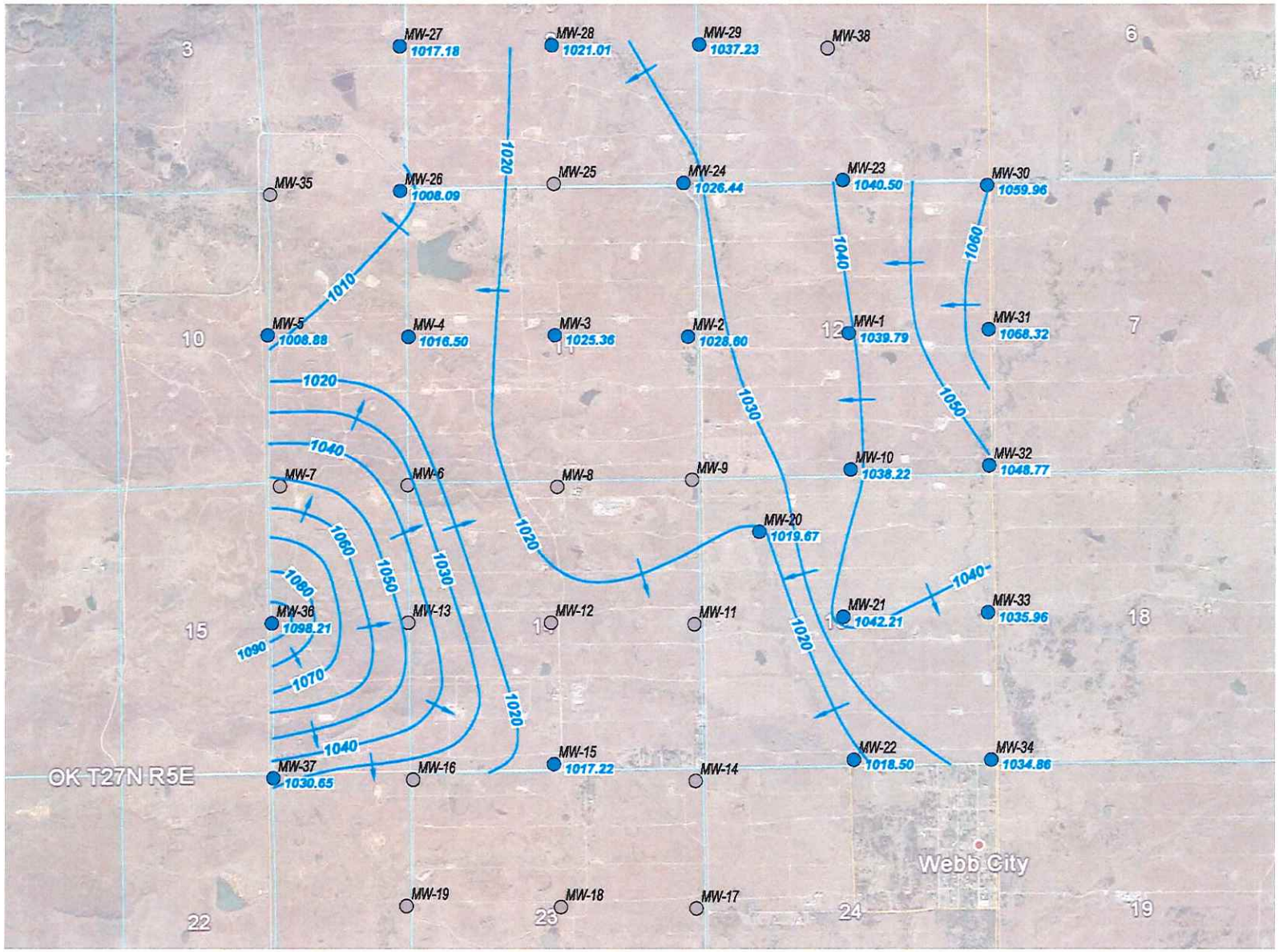
Vanoss A Groundwater Potentiometric Surface



Vanoss B Groundwater Potentiometric Surface



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Preliminary Estimate of Groundwater Flow Velocities

Based upon reference documents and site-specific hydraulic gradients the following estimated groundwater flow velocities can be calculated:

- **Vanoss A Sandstone**
  - Reference documented hydraulic conductivities ranging from 0.4 to 2 feet/day
  - Measured hydraulic gradient of 0.0112 feet/foot
  - Reference documented effective porosity of 0.14
  - **Groundwater flow velocities ranging from 12 to 58 feet/year**

- **Vanoss B Sandstone**
  - Reference documented hydraulic conductivities ranging from 0.4 to 2 feet/day
  - Measured hydraulic gradient of 0.0040 feet/foot
  - Reference documented effective porosity of 0.14
  - **Groundwater flow velocities ranging from 4 to 21 feet/year**

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Review of Groundwater Analytical Results

- ECC evaluated the laboratory analytical results for the groundwater samples taken from the 38 monitoring wells.
- In an effort to identify wells that may require additional well development ECC looked for wells that have the following criteria:
  - Wells that appear to have initial samples that do not compare well with subsequent quarterly sample results (unreasonable baselines).
  - Wells that appear to have erratic quarterly sample results.

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Conclusions Regarding Quarterly Monitoring Results

- Groundwater analytical results do not appear to be consistent with monitoring wells that have been properly installed, developed, purged, sampled and analyzed.

- Monitoring wells should be re-developed to ensure water samples being collected quarterly are truly representative of groundwater.

- Wells should be re-surveyed to ensure hydraulic head interpretations are based upon accurate elevation datums (top casing elevations).

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Results of Well Re-Development

During the period August 25 through September 15, 2015, all 38 groundwater monitoring wells were aggressively re-developed by brushing and surging the well casings. The following observations were made and conclusions reached:

- All monitoring wells have low groundwater yields.
- Considerable silt levels and strong cement odor observed in all wells.
- Wells yields were improved in most wells through the aggressive re-development activities.
- All wells were completely evacuated during re-development. Average casing volume approximately 70 gallons.
- Levels of pH greater than 10 SU in 25 wells, and greater than 12 in 16 of those wells.

Chaparral ENERGY | **Results of Well Re-Development**

Previous Slide - Continued

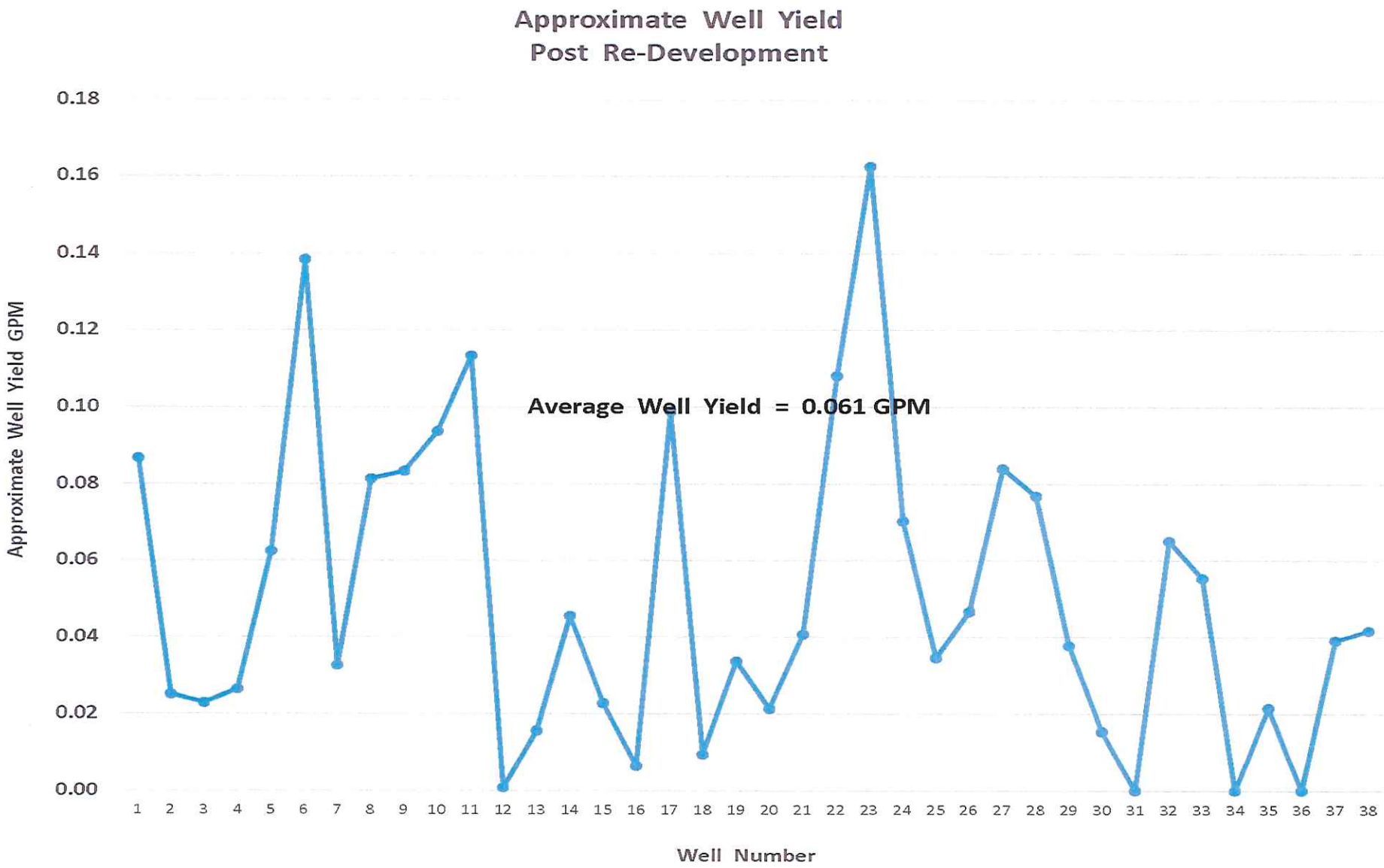
- Well recharge rates (measured with well casings fully evacuated) improved to an average of 0.061 feet per minute.

- MW-12 has exceptionally low recharge rate of 1.2 GPD following full evacuation. Requires approximately 2 months to recharge fully following evacuation. DTW measurements may not be reliable.

- Samples collected prior to Q3/2015 employed low-flow purging/sampling methods where approximately 10 gallons per well per event.

- Q3/2015 sampling event conducted soon after well re-development activities. Purging and sampling methods modified to conventional complete evacuation of the well casing and sampling when well had produced enough water to sample.

Yield of Monitoring Wells



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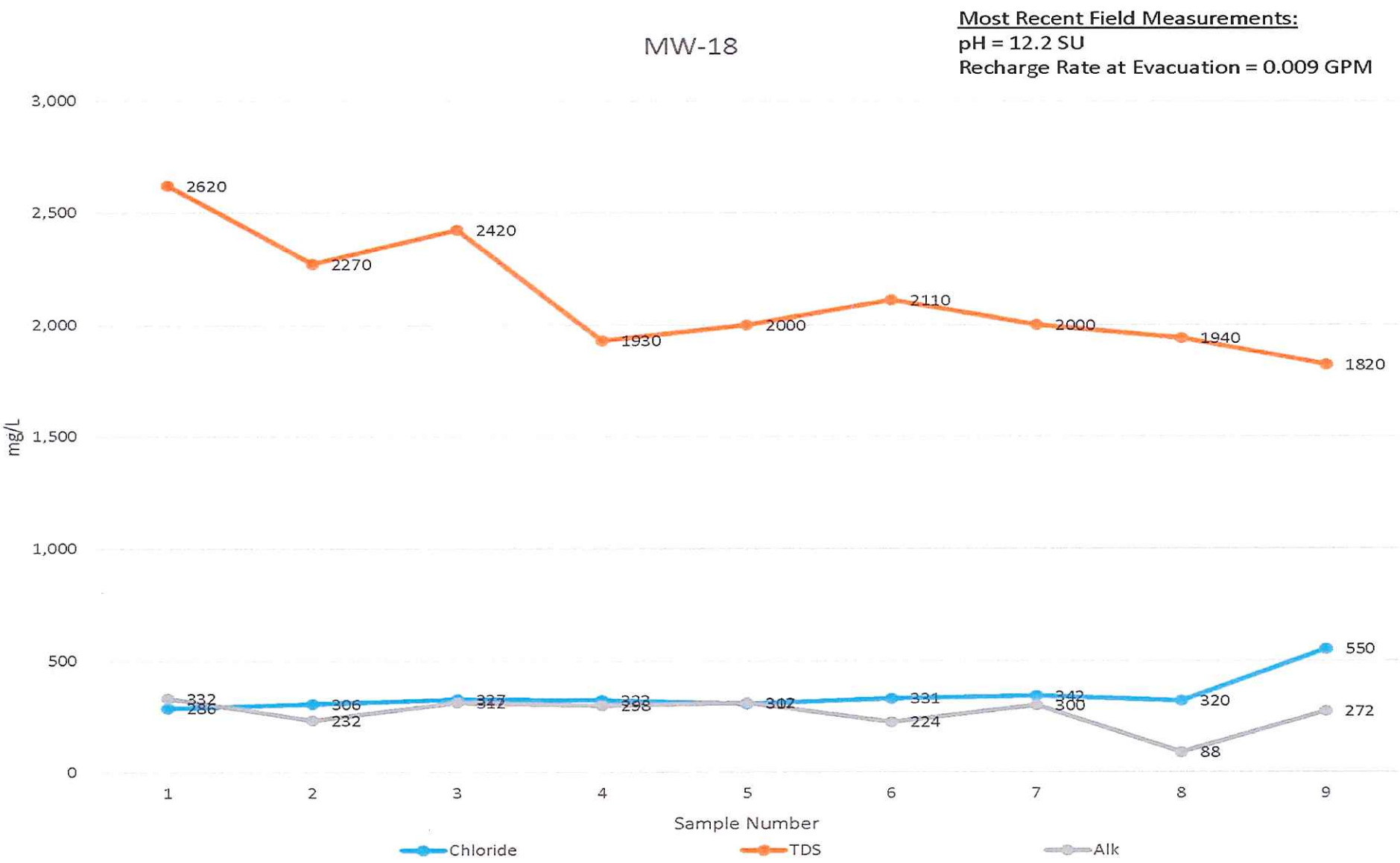
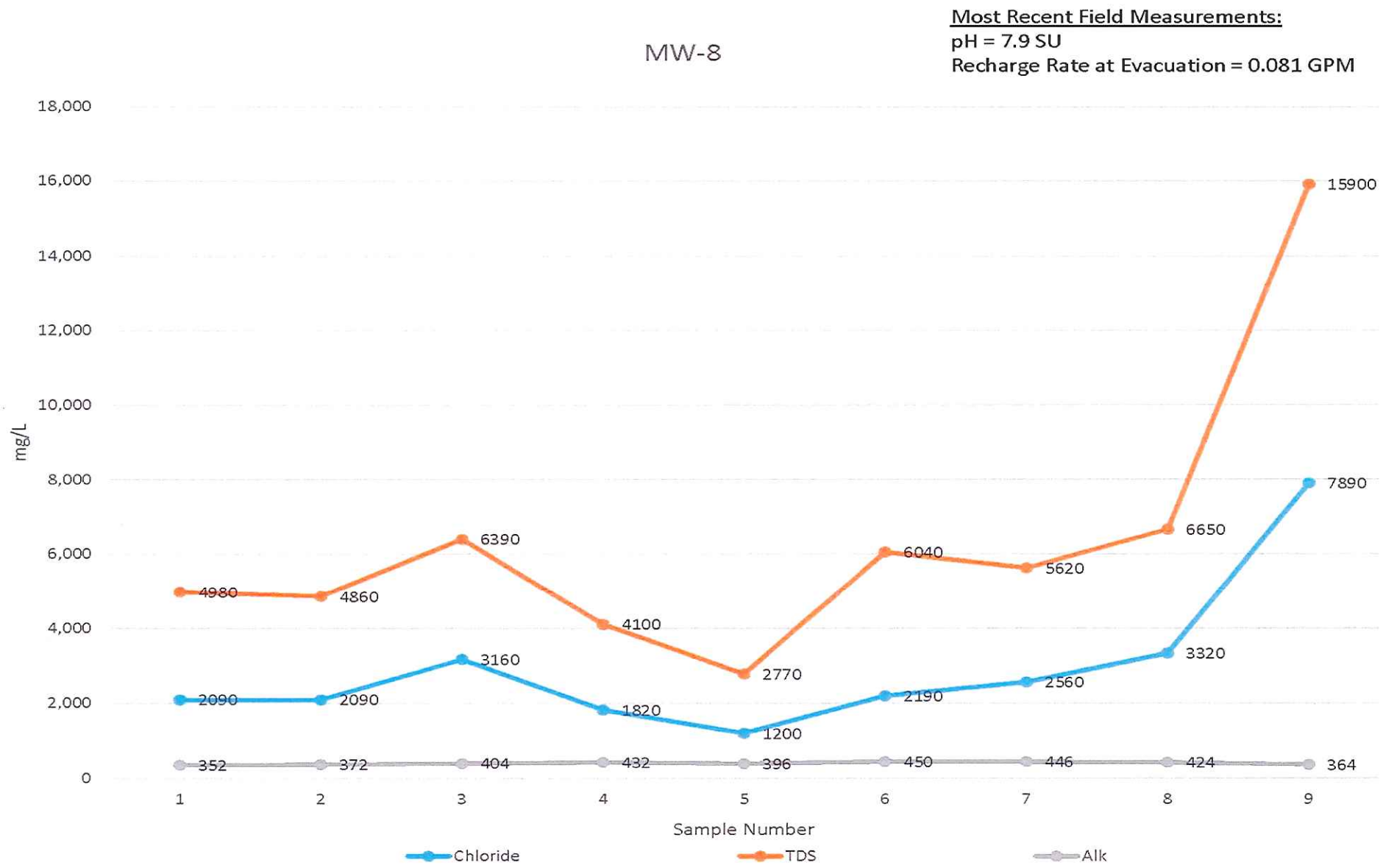
Review of Groundwater Analytical Results

- **7** wells appear to have reasonable baselines and stable quarterly trends including wells MW-3, 4, 12, 18, 19, 25 and 31.
- **10** wells appear to have reasonable baselines, but erratic quarterly trends including wells MW-7, 8, 9, 10, 11, 13, 16, 21, 33 and 35.
- **5** wells appear to have reasonably stable quarterly trends, but poor baselines including wells MW-1, 17, 20, 28 and 30.
- **16** wells appear to have poor baselines and also have erratic quarterly trends including wells MW-2, 5, 6, 14, 15, 22, 23, 24, 26, 27, 29, 32, 34, 36, 37 and 38.

Reasonable Baseline / Stable Trend

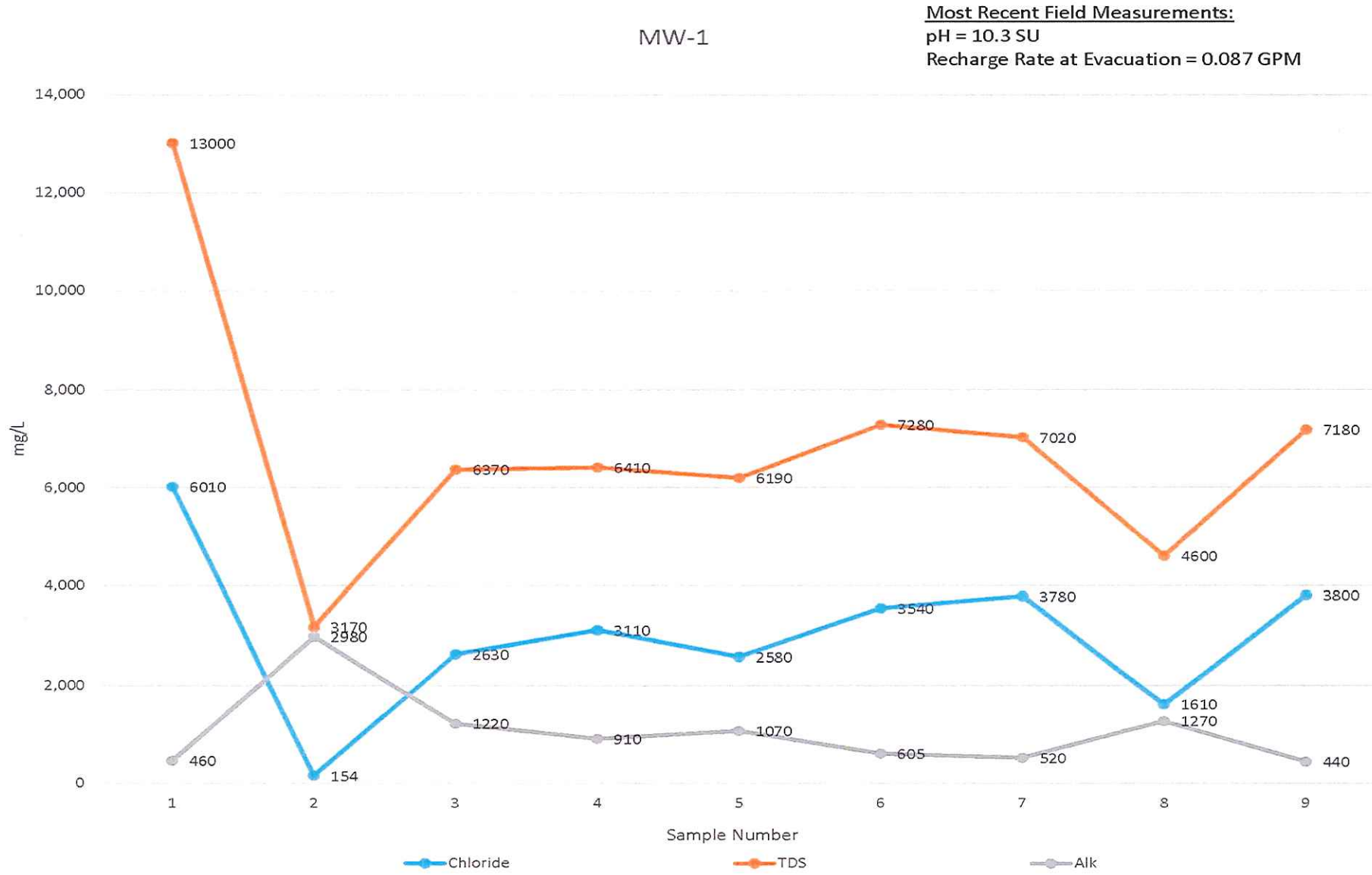


Reasonable Baseline / Unstable Quarterly Trends

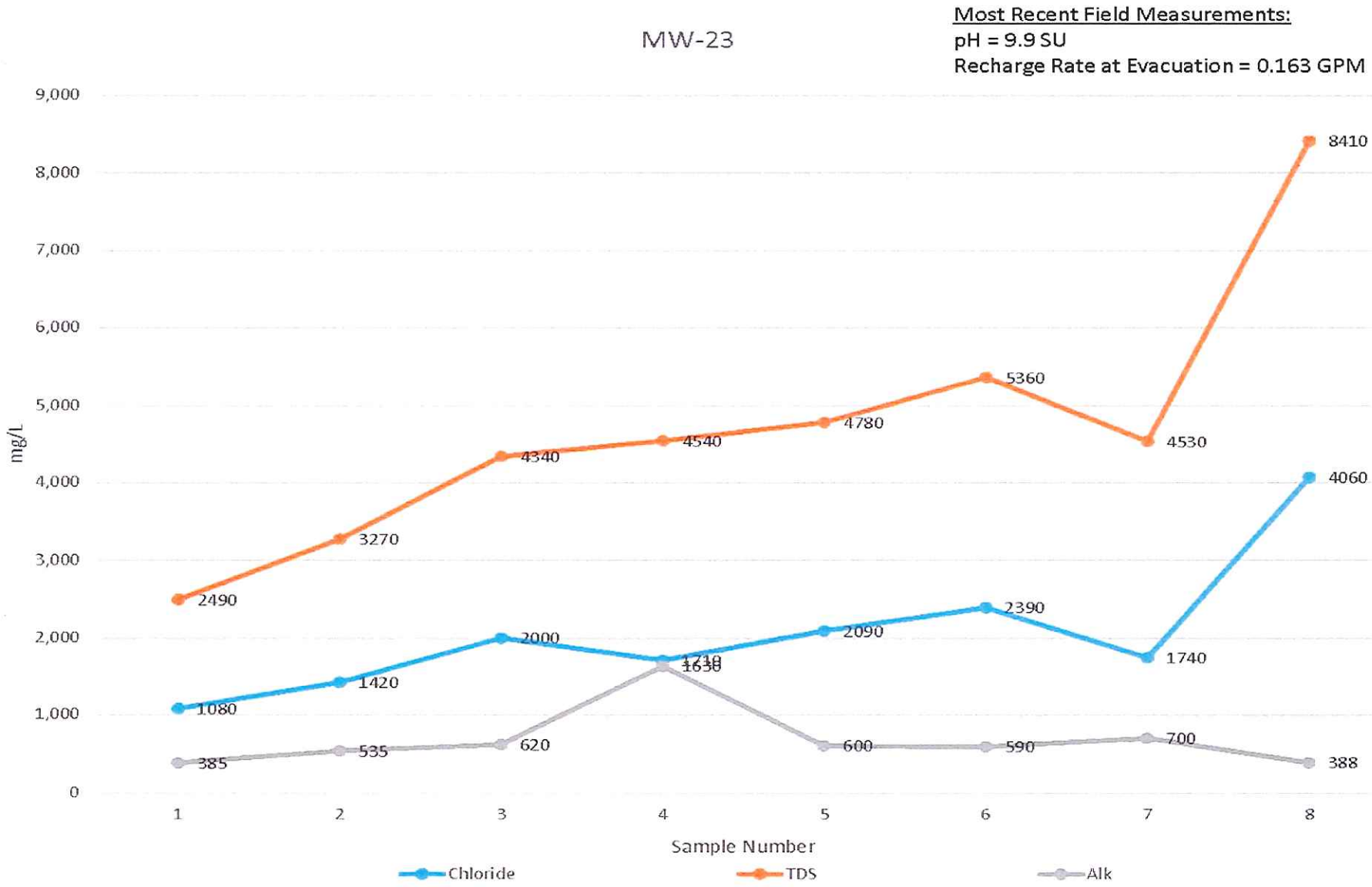


Stable Quarterly Trends / Unreasonable Baseline

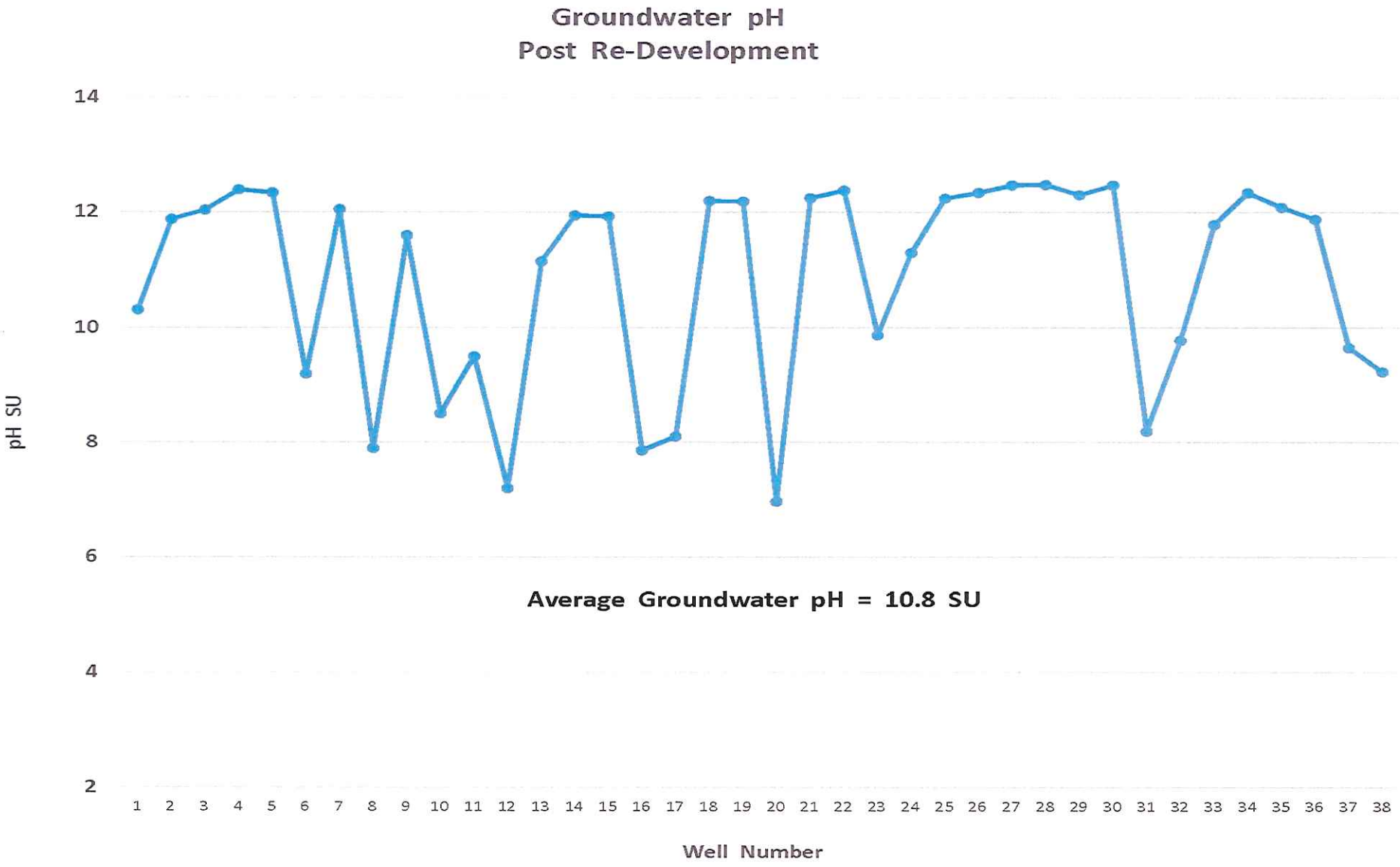
Most Recent Field Measurements:
pH = 10.3 SU
Recharge Rate at Evacuation = 0.087 GPM



Unreasonable Baseline / Unstable Quarterly Trends



Yield of Monitoring Wells



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ECC Recommendations For Quarterly Sampling

- Continue quarterly sampling in accordance with Permit and approved SAP and QAPP.
- Continue to develop high pH wells to reduce levels.
- Purge wells using conventional methods (complete evacuation / sample when adequately recharged) until wells are fully developed and analytical results are following a more consistent trend.
- Perform extended purging of wells with pH levels greater than 10 SU.
- Well MW-12 has exceptionally low yield (0.0008 GPM) and should not be relied upon for hydraulic head levels. Well may need to be replaced.

EPA Amended Administrative Order – February 5, 2015

The Amended Order provided the following regarding Groundwater monitoring requirements:

- Wells 23-08 and 24-05 were plugged back and completed as groundwater monitoring/recovery wells of the USDWs.
- Groundwater samples to be collected monthly from wells 23-08, 24-05 and MW-12 and be analyzed for TPH, VOC and typical ions including bicarbonate, bromide, calcium, carbonate, chloride, fluoride, magnesium, potassium, sodium and sulfate.
- Reports to be submitted to EPA and BIA quarterly.
- Oral reports required to be given to EPA if reports indicate contamination by the following business day.

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Status of Monthly Sampling Program

- Benzene has not been detected well MW-12 groundwater samples since well redevelopment (2 events thus far).

- Well MW-12 is being considered for replacement because of exceptionally low yield. Samples may not be representative of actual groundwater and water levels may not be reliable for hydraulic head assessment.

- Recovery wells 23-08 and 24-05 were former oil production wells that had been plugged. Their boreholes and casings were suspected as being CO_2 conduits to the ground surface and were cleaned out and re-plugged. Re-plugging appeared to stop CO_2 outbreak in area.

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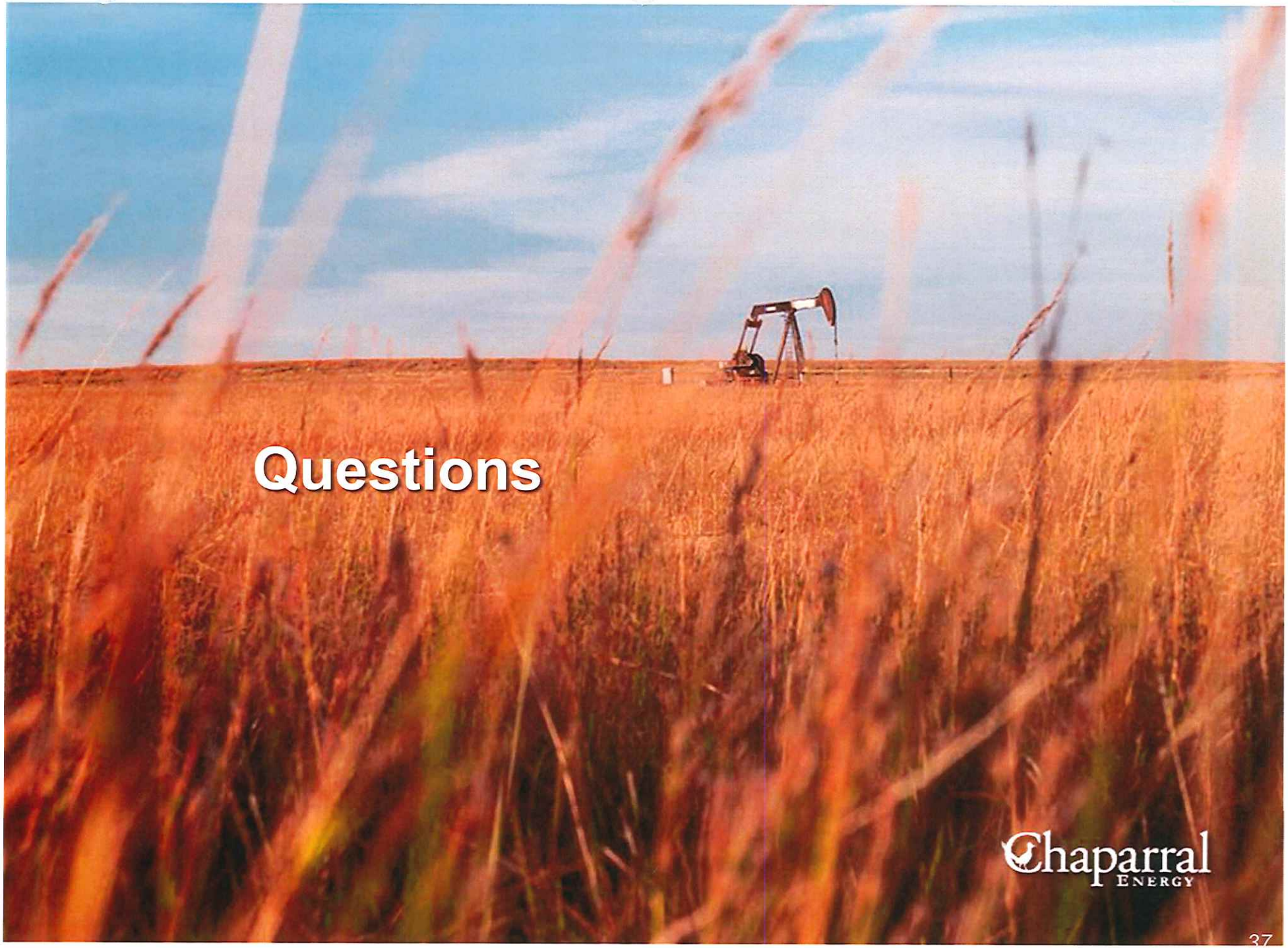
Status of Monthly Sampling Program

- Recovery wells 23-08 and 24-05 currently awaiting BIA permission to plug and abandon as they appear to not be suitable for groundwater recovery.

- Monitoring well MW-39 is being considered to be installed tentatively between wells 23-08 and 24-05 and south towards monitoring well MW-12. This well to be used to monitor zones comparable to other monitoring wells.


Questions
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